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Process for the Preparation of Ammonia

The present invention is directed to the preparation of ammonia by catalytic conversion of an ammonia synthesis gas.

5 Conventionally, industrial ammonia synthesis is based on conversion of ammonia synthesis gas consisting of hydrogen and nitrogen in a substantially stoichiometric mole ratio of 3:1. The synthesis gas is passed at high pressure  
10 through a fixed bed of ammonia catalyst particles of mainly magnetite, which is converted by reduction into the catalytically active form of  $\alpha$ -iron.

The process performance is governed not only by the catalyst composition, but also by the size and shape of the  
15 catalyst particles. For ammonia synthesis processes operating at catalyst beds with an axial synthesis gas flow the usual catalyst particle size is in the range of 6-10 mm.

Due to a reduced flow resistance in radial flow type ammonia reactors the catalyst particle size employed in these  
20 reactors is between 1.5 and 3 mm.

It has now been found that process performance of ammonia synthesis still may be improved in terms of a higher ammonia product yield when employing in radial ammonia reactors  
25 a fixed catalyst bed of ammonia catalyst with a mixed composition of catalyst particles having a large size and small size. A mixture of large size and small size particles results in higher bulk density due to smaller particles  
30 pack in voids being formed between larger particles. Higher bulk density provides an increased amount of catalyst in the ammonia reactor resulting in a higher catalytic activity per reactor volume.

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Pursuant to the above finding, this invention is a process for the preparation of ammonia by contacting an ammonia synthesis gas with ammonia catalyst particles arranged in a fixed bed, wherein the fixed bed comprises catalyst particles of the ammonia catalyst with a particle size being in the range of less than 1.5 mm and larger than or equal with 0.2 mm.

By inclusion of a significant amount of particles with a size within the specified range, the bulk density increases causing a higher pressure drop over the catalyst bed, and, thereby, an improved flow distribution of the synthesis gas within the bed.

When operating the inventive process at industrial conditions an improved flow distribution of synthesis gas is obtained when the catalyst bed contains between 10% and 80% by volume of ammonia catalyst particles having a particle size below 1.5 mm.

The Table below summarizes the relative density of different particle sizes of conventional ammonia catalysts commercially available from Haldor Topsøe A/S.

Table

Particle Size/mm		$\rho$ rel.
1.5-3.00		1.00
0.8-1.5		0.97
0.3-0.8		0.95
60%	1.5-3.0 +	1.09
20%	0.8-1.5 +	
20%	0.3-0.8	

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A mixture containing 60%, 20% and 20% of 1.5-3 mm, 0.8-1.6 mm and 0.3-0.8 mm particles, respectively, has a relative bulk density of 1.09.

- 5 The absolute bulk density of the industrial catalyst depends on the loading procedure, however, the same relative density can be found.

10 Inclusion of 0.2-1.5 mm sized catalyst particles provides higher catalyst bulk density, and also a lower diffusion resistance. By the broader particle size distribution and the increased bulk density a higher pressure drop is obtained over the catalyst bed causing a significant improved flow distribution of the synthesis gas in the catalyst bed.

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At present a preferred particle size distribution of ammonia catalyst arranged as fixed bed is obtained by mixing particles with a size of 1.5-3.0 mm, 0.8-1.5 mm, and 0.3-0.8 in a weight ratio of 40-70 : 10-40 : 10-30.

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